$1.00

Simpson

INSTRUMENTS THAT STAY ACCURATE

# OPERATOR'S MANUAL

**WARNING**

For safe usage, it is essential that the operator read this manual carefully before using the instrument for any measurements.

## SIMPSON 460-2 DIGITAL VOLT-OHM-MILLIAMMETER

SIMPSON ELECTRIC COMPANY

853 Dundee Ave., Elgin, Illinois 60120
Area Code 312, Telephone 697-2260
In Canada, Bach-Simpson, Ltd., London, Ontario

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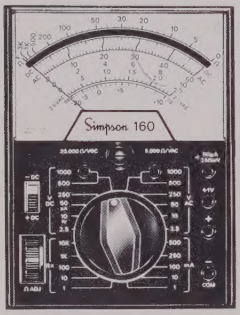


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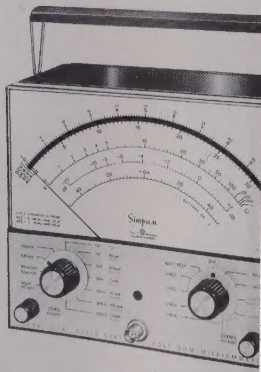

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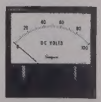

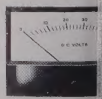

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# OPERATOR'S MANUAL

## SIMPSON 460-2
## DIGITAL
## VOLT-OHM-MILLIAMMETER

SIMPSON ELECTRIC COMPANY
853 Dundee Ave., Elgin, Illinois 60120
Area Code 312, Telephone 697-2260
In Canada, Bach-Simpson, Ltd., London, Ontario

Printed in U.S.A.
Rev. 10-74 HINZ

Part No. 5-116602

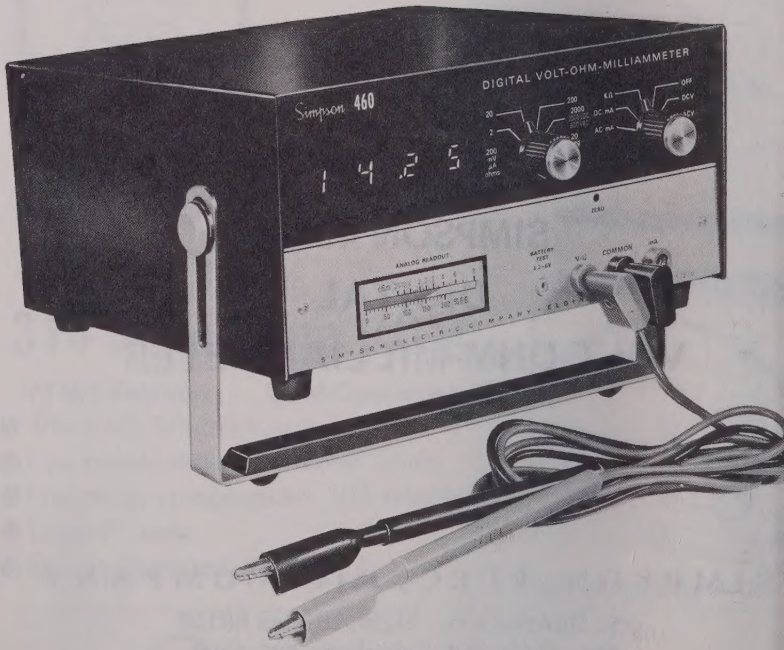


Figure 1-1. Simpson 460-2 Digital Volt-Ohm-Milliammeter

# TABLE OF CONTENTS


**SECTION I**

**Introduction** . . . . . 1-0

1.1 General . . . . . 1-0
1.2 Accessories and Supplies . . . . . 1-1
1.3 Technical Data. . . . . 1-1

**SECTION II**

**Installation** . . . . . 2-0

2.1 Unpacking and Inspection . . . . . 2-0
2.2 Power Source Requirements . . . . . 2-0
2.3 Installation . . . . . 2-1

**SECTION III**

**Controls, Connectors and Indicators** . . . . . 3-0

3.1 General . . . . . 3-0
3.2 Front and Rear Panel Description . . . . . 3-0

**SECTION IV**

**Operation** . . . . . 4-0

4.1 General . . . . . 4-0
4.2 Safety Precautions . . . . . 4-2
4.3 Preliminary Notes and Checks . . . . . 4-4
4.4 DC Voltage Measurements . . . . . 4-7
4.5 AC Voltage Measurements . . . . . 4-8
4.6 Resistance Measurements . . . . . 4-10
4.7 DC Current Measurements . . . . . 4-12
4.8 AC Current Measurements . . . . . 4-14

SECTION V

**Theory of Operation** . . . . . 5-1

5.1 Overall System . . . . . 5-1
5.2 Input Circuits . . . . . 5-1
5.3 Digital Voltmeter Circuit . . . . . 5-8
5.4 Power Supply Circuits . . . . . 5-12

SECTION VI

**Maintenance** . . . . . 6-1

6.1 General . . . . . 6-1
6.2 Warranty . . . . . 6-1
6.3 Shipping . . . . . 6-2
6.4 Cover Removal . . . . . 6-2
6.5 Battery Installation . . . . . 6-3
6.6 Battery Recharging . . . . . 6-4
6.7 Battery Care . . . . . 6-5
6.8 Fuse Replacement . . . . . 6-5
6.9 Zero Adjustment . . . . . 6-7
6.10 Knob Removal . . . . . 6-7
6.11 Preventive Maintenance . . . . . 6-8
6.12 Troubleshooting . . . . . 6-10

SECTION VII

**Ordering Information, Schematic Diagram and Authorized Service Centers** . . . . . 7-1

## LIST OF TABLES


1-1 Technical Data . . . . . 1-2
3-1 Front and Rear Panel Description . . . . . 3-0
4-1 DC Voltage Ranges and Connections . . . . . 4-8
4-2 AC Voltage Ranges and Connections . . . . . 4-10
4-3 Resistance Ranges and Connections . . . . . 4-11
4-4 DC Current Ranges and Connections . . . . . 4-14
4-5 AC Current Ranges and Connections . . . . . 4-15
6-1 Troubleshooting Chart . . . . . 6-12
7-1 Items Furnished With Instrument . . . . . 7-1
7-2 Replacement Parts List . . . . . 7-6


## LIST OF ILLUSTRATIONS


1-1 Simpson 460-2 Digital Volt-Ohm-Milliammeter . . . . . i
3-1 Front and Rear Panel Description . . . . . 3-1
3-2 Simpson 460-2 Rear Panel . . . . . 3-1
5-1 Basic System Diagram . . . . . 5-3
5-2 Basic Voltage Measurement Circuits . . . . . 5-4
5-3 Basic DC Current and Resistance Measurement Circuits . . . . . 5-7
5-4 Block Diagram of Digital Voltmeter . . . . . 5-9
5-5 Simpson 460-2 Basic Timing Diagram . . . . . 5-11
5-6 Simpson 460-2 Power Supply, Schematic . . . . . 5-13
6-1 Simpson 460-2 Fuse Location . . . . . 6-6
7-1 Simpson 460-2 , Schematic Diagram . . . . . 7-12

# SECTION I

# INTRODUCTION

## 1.1 GENERAL

**1.1.1** The Simpson 460-2 Digital Volt-Ohm-Milliammeter is a compact, 3-1/2 digit digital multimeter used for laboratory and portable applications. It features 0.1% accuracy, solid-state integrated circuit electronics, self-contained AC line and battery operation, and solid-state LED display. Through the use of an MOS-LSI integrated circuit, a special feature of automatic blanking of unused digits is incorporated to conserve battery power and to improve display readability. Additional features are automatic polarity, excellent temperature and overranging characteristics, and analog indication with both dBm and percent of full-scale markings on the meter dial.

**1.1.2** The 460-2 measures DC and AC voltage, DC and AC current and resistance as specified in Table 1-1. The dual-slope integration technique is used for the analog-to-digital conversion, because of its inherently excellent stability, accuracy and noise immunity. The careful use of integrated circuitry achieves high reliability, low power dissipation, and a compact design.

**1.1.3** The Simpson 460-2 can be operated from a 120 or 240 volts AC (50, 60 or 400 Hz) power source (check rear panel designation). For applications requiring complete

isolation from the power line, or when the AC line is not available, battery operation is provided using rechargeable, nickel-cadmium cells. The battery can operate the Instrument for nine hours continously. Recharging is automatic when the Instrument is in the OFF position and with the line cord connected. In an emergency, commercially available "D" size (flashlight type) batteries can be used. Refer to paragraph 6.5.1 for precautions and instructions.

**1.1.4** The numerical display is a 7-segment light-emitting-diode (LED) display for easy viewing and solid-state reliability. The numerals are 0.33 inch high and in a single plane for distant and wide-angle viewing. Ambient lighting effects are minimized by a filter which reduces reflections and background illumination.

**1.1.5** The analog meter provides quick and convenient indications for nulling, peaking, scanning and varying signal applications. Both linear and decibel (dBm) readings are shown on the analog readout.

## 1.2 ACCESSORIES AND SUPPLIES

All supplies and accessories required for the operation of the Instrument (using line power) are furnished with the Instrument and listed in Table 7-1. Batteries are not supplied.

## 1.3 TECHNICAL DATA

Table 1-1 lists the technical specifications for the Simpson 460-2 Digital Volt-Ohm-Milliammeter.

Table 1-1. Technical Data

## 1. DC Voltage:

| Range | Maximum Indication | Input Impedance | Overload Protected To |
|---|---|---|---|
| 200 mV | 199.9 mV | ≥100 MΩ | 350 V |
| 2 V | 1.999 V | ≥1000 MΩ | 350 V |
| 20 V | 19.99 V | 10 MΩ | 1000 V |
| 200 V | 199.9 V | 10 MΩ | 1000 V |
| 1000 V | 1000 V (max. input) | 10 MΩ | 1100 V |

| | |
|---|---|
| Accuracy: (from +10°C to +40° C) | ± (0.1% of reading + 1 digit) |
| Input Bias Current: | 7 nA maximum at reference conditions |
| Resolution: | 100 microvolts on 200 mV range |
| Overrange Capability: | Linear to 500 counts beyond maximum indication (except on 1000 V range, where any indication greater than 1100 is an overload) |
| Temperature Coefficient: (from 0° C to + 55° C) | ± (0.005% of reading + 0.1 digit)/C° |

| | |
|---|---|
| Full Scale Step Response: (to within rated accuracy) | 2 seconds, maximum |
| Normal Mode Rejection: | 35 dB minimum at 60 Hz |
| Common Mode Rejection: | 80 dB minimum at 60 Hz with 1000Ω unbalance.<br><br>100 dB minimum at DC with 1000 Ω unbalance. |

## 2. Resistance:

| Range | Maximum Indication | Test Current | Overload Protection |
|---|---|---|---|
| 200Ω | 199.9Ω | 1 mA | *250 V rms |
| 2 kΩ | 1.999 kΩ | 100μA | *250 V rms |
| 20 kΩ | 19.99 kΩ | 10 μA | 250 V rms |
| 200 kΩ | 199.9 kΩ | 10 μA | 250 V rms |
| 2000 kΩ | 1999 k Ω | 1 μA | 250 V rms |
| 20MΩ | 19.99 MΩ | 100 nA | 250 V rms |

*Fuse protected

| | |
|---|---|
| Accuracy: (from +10°C to +40°C) | ± (0.5% of reading + 1 digit) except on the 20 MΩ range, which is ± (1% of reading + 1 digit) |

| | |
|---|---|
| Resolution: | 0.1 Ohm on 200Ω range |
| Overrange Capability: | Linear to 500 counts beyond maximum indication |
| Temperature Coefficient: (from 0°C to +55°C) | ± (0.05% of reading +0.1 digit)/C° |
| Full Scale Step Response: (to rated accuracy) | 2 seconds, except 6 seconds on the 20 MΩ range |

### 3. AC Voltage (Average-Sensing, RMS-Calibrated Sine Wave):

| Range | Maximum Indication | Input Impedance | Overload Protected To |
|---|---|---|---|
| 200 mV | 199.9 mV | 1 MΩ and 150 pF | 350 V rms |
| 2V | 1.999 V | 1 MΩ and 150 pF | 350 V rms |
| 20 V | 19.99 V | 1 MΩ and 150 pF | 600 V rms |
| 200 V | 199.9 V | 1 MΩ and 150 pF | 600 V rms |
| 600 V | 600 V (max. input) | 1 MΩ and 150 pF | 600 V rms |

| | |
|---|---|
| Accuracy: (from +10°C to +40°C) | ± (0.5% of reading + 1 digit) 40 Hz to 10 kHz<br>± (1.0% of reading +1 digit) 10 kHz to 20 kHz |

| | |
|---|---|
| Resolution: | 100 microvolts on 200 mV range |
| Overrange Capability: | Linear to 500 counts beyond maximum indication (except on 600V range, where any indication greater than 600 is an overload) |
| Full Scale Step Response: (to rated accuracy) | 5 seconds maximum |
| Temperature Coefficient: (from 0°C to +55°C) | ± (0.05% of reading + 0.1 digit)/C° |

## 4. DC CURRENT:

| Range | Maximum Indication | Full Range Voltage Drop | Overload Protected To* |
|---|---|---|---|
| 200 μA | 199.9 μA | 200 mV | 3 Amps |
| 2 mA | 1.999 mA | 200 mV | 3 Amps |
| 20 mA | 19.99 mA | 200 mV | 3 Amps |
| 200 mA | 199.9 mA | 200 mV | 3 Amps |
| 2000 mA | 1999 mA | 200 mV | 3 Amps |

*Fuse protected

| | |
|---|---|
| Accuracy: (from +10°C to +40°C) | ± (0.2% of reading + 1 digit) except on 2000 mA range, which is ± (0.5% of reading + 1 digit) |

| | |
|---|---|
| Resolution: | 100 nanoamps on 200 $\mu$A range |
| Overrange Capability: | Linear to 500 counts beyond maximum indication |
| Full Scale Step Response: (to rated accuracy) | 2 seconds maximum |
| Temperature Coefficient: (from 0°C to + 55°C) | $\pm$ (0.01% of reading + 0.1 digit)/C° |

## 5. AC CURRENT (40 Hz to 10 kHz):

| Range | Maximum Indication | Full Scale Voltage Drop | Overload Protected To* |
|---|---|---|---|
| 200 $\mu$A | 199.9 $\mu$A | 200 mV | 3 Amps |
| 2 mA | 1.999 mA | 200 mV | 3 Amps |
| 20 mA | 19.99 mA | 200 mV | 3 Amps |
| 200 mA | 199.9 mA | 200 mV | 3 Amps |
| 2000 mA | 1999 mA | 200 mV | 3 Amps |

*Fuse protected

| | |
|---|---|
| Accuracy: (from +10°C to +40°C) | $\pm$ (0.7% of reading + 1 digit), except on 2000 mA range, which is $\pm$ (1.0% of reading + 1 digit) |

| | |
|---|---|
| Overrange Capability: | Linear to 500 counts beyond maximum indication |
| Full Scale Step Response: (to rated accuracy) | 5 seconds maximum |
| Temperature Coefficient: (from 0°C to +55°C) | ± (0.05% of reading + 0.1 digit)/C° |

**6. MAX. COMMON MODE VOLTAGE:** 600 volts (DC plus peak AC) maximum from COMMON terminal to power line ground terminal

**7. DISPLAY:**

| | |
|---|---|
| Numerical Display: | 3-1/2 digits. 7-segment light-emitting-diode (LED) type, non-blinking with storage. Automatic blanking of non-significant zeros. |
| Conversion Rate: | 4 readings per second, nominal |
| Overrange Indication: | Automatic beyond 1999:<br>a) Between 2000 and 2999 counts, upper half of the "1" digit is blanked. |

b) 3000 counts or greater, the whole display is blanked.

| | |
|---|---|
| DC Polarity Selection: | Automatic with "+" or "-" indication. |
| Analog Display: | Rotating drum meter with both linear and dBm scale markings. |

## 8. POWER REQUIREMENTS:

| | | |
|---|---|---|
| a. | AC Operating or Battery Charging: | 120 VAC or 240 VAC ± 10% (check rear panel designation). 50, 60, or 400 Hz, 7 VA nominal. |
| b. | Battery Operation: | Four nickel-cadmium "D" size rechargeable cells, Eveready type CH4 or equivalent; each cell is rated at 1.25 V, 4 ampere-hours. |
| c. | Operation time (continuous with fully charged battery) | 9 hours nominal |
| d. | Recharge time (function switch in OFF position) | 16 hours nominal |
| e. | Recharge time (while Instrument is in operation) | 30 hours nominal |

**9. TEMPERATURE RANGE:**

| | |
|---|---|
| Operating: | 0° C to +55° C |
| Storage: | -40° C to +60° C |

**10. REFERENCE CONDITIONS:**

| | |
|---|---|
| Temperature: | +25° C ±1° C |
| Relative Humidity: | 30 to 60% |
| Atmospheric Pressure: | 575 to 800 mm Hg |

**11. WEIGHT:** 4.5 pounds (6.5 pounds with battery)

**12. DIMENSIONS:** 4" high, 8.5" wide 8" deep (not including panel controls)

## SECTION II

## INSTALLATION

### 2.1 UNPACKING AND INSPECTION

**2.1.1** Examine the shipping carton for signs of damage prior to unpacking. If there is none, then unpack and inspect the Instrument for possible damage in shipment. Check the electrical performance as soon as possible. If damage is noted, notify the carrier and supplier before using the Instrument. Also check that all items are included (Table 7-1).

**2.1.2** Save the shipping carton and packing materials for future storing or shipping of the Instrument.

### 2.2 POWER SOURCE REQUIREMENTS

**2.2.1** The Simpson 460-2 is designed to be operated from either the AC line or self-contained nickel-cadmium cells (not furnished with the Instrument). Refer to Table 1-1.

**2.2.2** AC Line Operation: The Simpson 460-2 is wired at the factory for 120 VAC (50, 60 or 400 Hz) operation. To convert your Instrument for 240 VAC operation, consult your nearest Simpson Authorized Service Center.

CAUTION

**For AC line operation, insure that the grounding pin of the power plug is securely connected to an earth (power line) ground. Use a 3-wire grounded outlet which conforms to the latest electrical code.**

**2.2.3** Battery Operation:

WARNING

**Whenever the Simpson 460-2 is used with line cord disconnected, the rear panel GROUND terminal must be connected securely to earth ground.**

**2.3.3.1** The Simpson 460-2 is supplied without batteries. The cells required (refer to Table 1-1, item 8b) can be purchased from a local electronic parts distributor.

**2.2.3.2** Battery operation is automatic whenever cells are installed, the line cord is disconnected, and the function switch in other than the OFF position.

**2.2.3.3** For battery installation and battery test refer to 6.5.

## 2.3 INSTALLATION

The Instrument may be set horizontally on the bottom four rubber feet or vertically on the rear four feet and operated in either position. It also can be set at an inclined angle by positioning the carrying handle under the unit.

## SECTION III

## CONTROLS, CONNECTORS, AND INDICATORS

### 3.1 GENERAL

All operating and adjusting controls, connectors, and indicators are described in Table 3-1. Become familiar with each item prior to operating the Instrument for the first time.

### 3.2 FRONT AND REAR PANEL DESCRIPTION

Table 3-1 lists all front and rear panel controls, connectors and indicators (see Figure 3-1 and 3-2 for identification).

Table 3-1. Front and Rear Panel Description

**1. Function Selector Switch**

| Switch Position | Description |
|---|---|
| ACmA | Connects the COMMON and mA jacks to the AC current measuring circuits. |
| DCmA | Connects the COMMON and mA jacks to the DC current measuring circuits. |

Figure 3-1. Front Panel

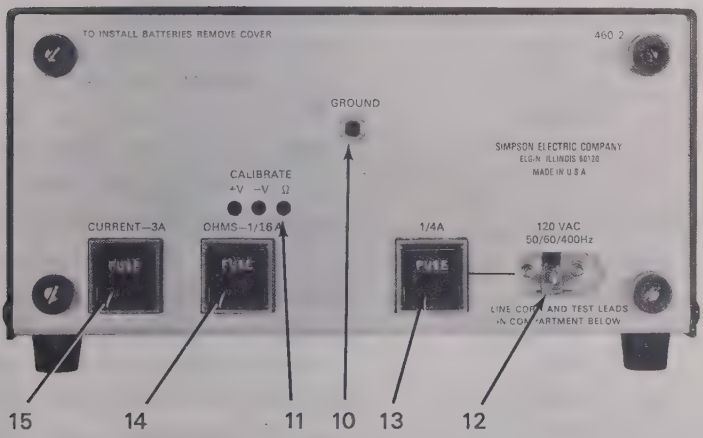


Figure 3-2. Rear Panel

| | |
|---|---|
| KΩ | Connects the COMMON and V-Ω jacks to the resistance measuring circuits. |
| OFF | Disconnects the AC power from all circuits except the battery charging circuit. |
| DCV | Connects COMMON and V-Ω jacks to the DC voltage measuring circuits. |
| ACV | Connects COMMON and V-Ω jacks to the AC voltage measuring circuits. |

## 2. Range Selector Switch

| Switch Position | Description |
|---|---|
| 200 mV<br>μA<br>ohms | Selects the circuits required for full range measurements of 0 to ±200 mV DC, 0 to 200 mV AC, 0 to ±200 μA DC, 0 to 200 μA AC, 0 to 200 ohms, depending on the position of the function switch. |
| 2, 20,<br>200,<br>2000,<br>1000 VDC<br>600 VAC | Selects the circuits required for full range measurements of 0 to the corresponding numerical values of AC mA, ±DC mA, KΩ , ±DC V or AC V depending on the position of the function switch. |

| | |
|---|---|
| 20 meg Ω | Selects the circuits required for the full range measurement of resistance from 0 to 20 MΩ when the function switch is set to the KΩ position. |

### 3. COMMON jack

This jack is used to connect the "low" side of the circuit being measured to the internal circuit ground and is isolated from the AC power line ground. However, do not "float" this terminal more than 600 volts (DC plus AC peak) away from case (power line ground) potential.

### 4. V- Ω jack

This terminal is used to connect the "high" side of the circuit being measured to all voltage and resistance measuring circuits through the range and function switches.

### 5. mA jack

This terminal is used to connect the "high" side of the currents being measured to the current measuring circuits through the function and range switches. The "low" side is connected to the COMMON jack.

### 6. BATTERY TEST 4.7 - 6V jack

This jack connects to the positive terminals of the battery

(through an isolation resistor) when the battery is installed. For battery test, connect a test lead between the V-Ω jack and the BATTERY TEST jack, with the function selector switch set in the DCV position and the range selector switch set in the 20 position. The numerical display must indicate a voltage between +4.7 volts and + 6.0 volts for proper operation. If the display indicates greater than +6.0 volts, either the battery is not installed or the battery is not installed properly.

## 7. ANALOG READOUT

The analog meter displays in analog form the relative value of the input signal being measured. The reading is determined in conjunction with the position setting of the range switch. Two scale markings are provided: a linear scale and a decibel scale marked −20 dBm to +8 dBm. The value displayed is read from the intersection of the red marker and the markings on the dial. For example, a value of "100" on the bottom scale ("1000" digital indication) corresponds to approximately +3 dBm on the top scale. The dBm readings on the scale are referenced to 0 dBm power level of 1 milliwatt into a 600Ω load (an actual voltage of 0.775V.) The actual decibel value is determined by:

(1) Reading the dBm scale value, and

(2) adding the appropriate range factor as follows:

| RANGE | ADD |
|---|---|
| 200 mV | -20 dBm |
| 2 V | 0 dBm |
| 20 V | +20 dBm |
| 200 V | +40 dBm |
| 600 V | +60 dBm |

## 8. Zero Adjustment

The ZERO adjustment is a screwdriver-adjusted potentiometer used to correct for a DC offset voltage at the input to the integrator/amplifier. It is adjusted to obtain a numerical indication of .0 when the input terminals are shorted together, with the function switch set on the DCV and the range selector switch set on the 200 mV position.

## 9. Numerical Display

The digital display uses LED's and includes a polarity (+, -) sign, a "1" digit, three 7-segment type 0 to 9 digits and a decimal point, to indicate the polarity and the value of the signal being measured. The decimal point is properly positioned by the setting of the range selector switch. Overrange (or out-of-range) conditions are indicated by: (a) the upper half of the "1" digit is blanked for implied values between 2000 and 2999 counts, and (b) the whole display is blanked for input values corresponding to 3000 counts or greater.

### 10. GROUND jack

This terminal is electrically connected to the case and the AC line "third wire" ground. Connect this terminal to earth ground when in battery operation.

### 11. +V, -V, Ω

These adjustments are for calibrating the internal circuits to voltage and resistance standards.

NOTE: These adjustments shall be made only by a qualified technician knowledgeable of the precautions, procedures and equipment required.

### 12. AC Power Receptacle

This receptacle accepts the AC line power cord used for AC operation or battery charging.

### 13. Line Fuse

The AC power line fuse for 120V operation is 1/4A, 250V, type 3 AG, fast blow. For 240V operation, the fuse rating is 1/8A, 250V, type 3 AG, fast blow.

### 14. OHMS Fuse

This fuse is used to protect the resistance measuring circuits. The fuse rating is 1/16A, 250V, type 3 AG, fast blow.

## 15. CURRENT Fuse

This fuse is used to protect the current measuring circuits. The fuse rating is 3 A, 250V, type 3 AG, fast blow.

# SECTION IV

# OPERATION

## 4.1 GENERAL

**WARNING**

The Simpson 460-2 Digital Volt-Ohm-Milliammeter is designed to prevent accidental electrical shock when properly used. Naturally, no engineering design can render safe an instrument which is used improperly or carelessly. One form of carelessness is to use a piece of equipment without first reading and understanding (and then following!) the instructions. What might be the greatest carelessness of all is to assume that a circuit is wired and grounded the way you would have done it.

Much work has been done by governmental and other agencies to define clearly what constitutes an electrical shock hazard. As a guideline, and to indicate how involved the matter can become, we invite your attention to the following. This definition is given in the Underwriters Laboratories Radio and Television Receiving Appliances Standards for Safety, Twelfth Edition, dated June 25, 1969.

"Shock hazard shall be considered to exist at any part involving a potential of between 42.4 volts peak and 40 kilovolts peak in the following cases:

A. If the current through a load of not less than 500 ohms exceeds 300 milliamperes after 0.003 second.

B. If the current through a load of not less than 500 ohms exceeds 5 milliamperes after 0.2 second.

C. If the time required for the current through a load of not less than 500 ohms to decrease to 5 milliamperes is between 0.1 and 0.2 second, and the total quantity of electricity passed through the load up to that time exceeds 4 millicoulombs.

D. If the time required for the current through a load of not less than 500 ohms to decrease to .5 milliamperes is between 0.03 and 0.1 second, and the total quantity of electricity passed through the load up to that time exceeds $75T - 350T^2$ millicoulombs, where T is the time in seconds.

E. If the potential is more than 5 kilovolts peak and if the total capacitance of the circuit is more than 3000 micromicrofarads."

The strange value of 42.4 volts is simply the peak voltage of a sine wave of 30 volts rms. Above the quoted 40 kilovolts, additional considerations might apply.

## 4.2 SAFETY PRECAUTIONS

**4.2.1** Do not work alone when making measurements where a shock hazard can exist. Notify a person nearby that you are making, or intend to make, such measurements.

**4.2.2** Remember that voltages might appear unexpectedly in defective equipment. An open bleeder resistor can result in a capacitor's retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured before making connections or disconnections. The Instrument itself is well protected against electrical overload, as noted throughout Table 1-1. However, the above precautions are wise even in the laboratory, and especially in field usage of the Instrument where many strange or unknown safety hazards might prevail.

**4.2.3** Locate all voltage sources and accessibility paths prior to making any measurement or connections.

**4.2.4** For your own safety, inspect the test leads for cracks, breaks, or crazes in the insulation, prods and connectors before each use. If any defects exist, destroy and replace the defective item(s) immediately.

**4.2.5** Do not use test leads which differ from those originally furnished with the Instrument as common variety test leads might not provide adequate insulation required for the user's safety.

**4.2.6** Do not make measurements in a circuit where corona is present. Corona can be identified by a pale-blue color emanating from sharp metal points in the circuit, or a buzzing sound, or the odor of ozone. In rare instances, such as around germicidal lamps, ozone might be generated as a normal function. Ordinarily, the presence of ozone indicates presence of high voltage, and probably a malfunction of some kind.

**4.2.7** Hands, shoes, floor and workbench must be dry. Avoid making measurements under humid, damp, or other environmental conditions that could affect the dielectric withstanding voltage of the test leads or the Instrument.

**4.2.8** For maximum safety, do not touch test leads, circuit or Instrument while power is applied to the circuit being measured.

**4.2.9** Use extreme caution when making measurements in an rf circuit where a dangerous combination of voltages could be present, such as in a modulated rf amplifier.

**4.2.10** Before the Instrument is used for AC operation, make sure that the "third wire" on the AC power cord is connected to an earth or power line ground. This connection grounds the 460-2 case; therefore, it protects the user from a possible shock hazard in the event of a failure or misuse of the Instrument.

**4.2.11** Do not float the COMMON terminal more than 600 volts (DC plus AC peak) with respect to the case (power line ground) potential.

**4.2.12** Do not operate the 460-2 without knobs, or use knobs (or set screws) which differ from those originally supplied with the Instrument. The supplied knobs are designed to provide an extra margin of safety to the user. Improper knobs or set screws will reduce this safety margin.

## 4.3 PRELIMINARY NOTES AND CHECKS

Prior to operation of the instrument, review and perform (where applicable) the following notes and checks. These steps can be used also as a general functional check.

**4.3.1** For AC line operation, insure that the power source used matches the requirements of the Instrument as marked on the rear panel. Insert the plug into a 3-wire power outlet which conforms to the latest electrical code. The Instrument will operate with or without battery. When the Instrument is operating on the AC line with the internal battery installed, the battery is being "trickle" charged.

NOTE: Do not operate the Instrument with cells in the completely discharge state, which is common for all new cells as acquired from the vendor. Follow Preliminary Notes 4.3.3.

**4.3.2** For battery operation follow this procedure:

a. Disconnect the AC line Cord and set the function selector switch to the OFF position. Install four "D" size

nickel-cadmium cells (not supplied with Instrument). Observe polarity as shown on label inside battery holder.

b. Set the range selector switch to the 20 position and the function selector switch to the DCV position.

c. Connect a test lead between the V-Ω jack and the BATTERY TEST jack. The reading must be between +4.7 volts and +6.0 volts for proper operation of the Instrument.

d. If the battery voltage is below +4.7 volts, or if the display does not emit light, either the battery is improperly installed or recharging is required.

e. Prior to connecting the Instrument to any external circuit, the rear panel GROUND terminal must be grounded in accordance with paragraph 2.2.3.

NOTE: If the battery is not installed, or is not installed properly, the BATTERY TEST reading will be greater than +6 volts. This voltage is the open-circuit charging voltage for the battery.

**4.3.3** To recharge the battery, follow this procedure:

a. With the function selector switch set to the OFF position, insert the line cord plug into a 3-wire power outlet which conforms to the power requirements of the Instrument as marked on the rear panel, and to the latest electrical code.

b. The battery is being charged at full rate.

NOTE: If the battery test indicates a voltage below +4.7 volts, leave the Instrument in the OFF position for at least 15 minutes before operating.

c. Time for complete recharge of the battery is 16 hours nominal with the function switch set in the OFF position. Time for complete recharge of battery is nominally 30 hours while the Instrument also is being operated.

**4.3.4** For a general functional check, follow this procedure:

a. Connect the black test lead to the COMMON jack and the red test lead to the V-Ω jack. Short the test leads together.

b. Turn the function selector switch to the DCV position, and the range selector switch to the 200 mV position. The display will indicate .0 with the polarity sign alternating between "-" and "+".

c. Open the test leads. The numerical display will advance (due to input bias current) form .0 to -199.9, and into overrange. Soon the top half of the numeral "1" will extinguish and moments later the whole display will be blanked, indicating out-of-range.

d. Short the test leads together. The display reading will return to .0.

e. If difficulty is encountered in the above steps, see Section VI, paragraph 6.9 for Zero Adjustment procedure.

## 4.4 DC VOLTAGE MEASUREMENTS

CAUTION

**Prior to making connections, review and comply with the SAFETY PRECAUTIONS listed in paragraph 4.2.**

a. Review and comply with the Preliminary Notes and Checks, paragraph 4.3.

b. Connect input test leads to the V-Ω and COMMON terminals.

c. Turn the function selector switch to the DCV position.

d. Turn the range selector switch to the appropriate voltage range position as indicated in Table 4-1. If the voltage being measured is unknown, begin with the range selector switch set to the 1000 VDC position.

e. Turn off the power to the device or circuit under test and discharge all capacitors.

CAUTION

**Do not attempt to measure voltages on the 1000 VDC range which might be greater than 1100 volts DC.**

f. Connect test leads to the circuit being measured.

g. Apply power to the circuit being measured. The Instru-

ment will automatically indicate the correct polarity. The value of the voltage being measured will be indicated on the numerical display. The analog display will indicate the relative value and can be used for nulling or peaking applications.

h. Remove all power from the circuit being measured and discharge all capacitors prior to disconnecting test leads.

Table 4-1. DC Voltage Ranges and Connections

| Range | Range Switch Position | Function Switch Position | Input Connections | Max. Voltage | Remarks |
|---|---|---|---|---|---|
| 0 to 200 mV | 200 mV | DCV | V-Ω, COMMON | 350 V | Auto-polarity |
| 0 to 2 V | 2 | DCV | V-Ω, COMMON | 350 V | Auto-polarity |
| 0 to 20 V | 20 | DCV | V-Ω, COMMON | 1000 V | Auto-polarity |
| 0 to 200 V | 200 | DCV | V-Ω, COMMON | 1000 V | Auto-polarity |
| 0 to 1000 V | 1000VDC | DCV | V-Ω, COMMON | 1100 V | Auto-polarity |

## 4.5 AC VOLTAGE MEASUREMENT

CAUTION

**Prior to making connections, review and comply with the SAFETY PRECAUTIONS listed in paragraph 4.2.**

a. Review and comply with the Preliminary Notes and Checks, paragraph 4.3.

b. Connect input test leads to the V-Ω and COMMON terminals.

c. Turn the function selector switch to the ACV position.

d. Turn the range selector switch to the appropriate voltage range position as indicated in Table 4-2. If the voltage being measured is unknown, begin with the range selector switch set to the 600 VAC position.

CAUTION

**Do not attempt to measure voltages on the 600 V range which might be greater than 600 volts.**

e. Remove all power from the circuit being measured and discharge all capacitors.

f. Connect test leads to the circuit being measured.

g. Apply power to the circuit being measured. The value of the voltage being measured will be indicated on the numerical display. The analog display can be used for nulling or peaking applications. For decibel readings, see Table 3-1, Item 7 Analog Readout.

h. Remove all power from the circuit being measured and discharge all capacitors prior to disconnecting test leads.

Table 4-2. AC Voltage Ranges and Connections

| Range | Range Switch Position | Function Switch Position | Input Connections | Max. Voltage | Remarks |
|---|---|---|---|---|---|
| 0 to 200 mV | 200 mV | ACV | V-Ω, COMMON | 350 V rms | |
| 0 to 2 V | 2 | ACV | V-Ω, COMMON | 350 V rms | Frequency Range: 40 Hz to 20 kHz for all range positions |
| 0 to 20 V | 20 | ACV | V-Ω, COMMON | 600 V rms | |
| 0 to 200 V | 200 | ACV | V-Ω, COMMON | 600 V rms | |
| 0 to 600 V | 600 VAC | ACV | V-Ω, COMMON | 600 V rms | |

## 4.6 RESISTANCE MEASUREMENTS

a. Review and comply with the Preliminary Notes and Checks, paragraph 4.3.

b. Connect input test leads to the V-Ω and COMMON terminals.

c. Turn the function selector switch to the KΩ position.

d. Turn the range selector switch to the appropriate resistance range position as indicated in Table 4-3.

e. If the resistance being measured is connected into a circuit, be certain that all power is removed from the circuit and all capacitors are discharged. Check for current paths other than through the resistance being measured. These paths can result in a measured value which is lower than the actual value of the resistance being measured.

f. Connect the test leads to the resistance being measured. Be careful not to contact adjacent points, even if insulated, particularly when making high resistance measurements. Some insulators can have relatively low insulation resistance, which can sufficiently shunt the resistance being measured to result in a measured value lower than the presumed value.

NOTE: If the resistance being measured is polarity or voltage sensitive (for example, semiconductors), careful considerations must be given when making connections and selecting the resistance range (refer to Table 4-3).

Table 4-3. Resistance Ranges and Connections

| Range | Range Switch Position | Function Switch Position | Input Connections | Test Current |
|---|---|---|---|---|
| 0 to 200Ω | 200Ω | kΩ | V-Ω, COMMON | 1 mA |
| 0 to 2 kΩ | 2 | kΩ | V-Ω, COMMON | 100μA |
| 0 to 20 kΩ | 20 | kΩ | V-Ω, COMMON | 10μA |

Table 4-3. Resistance Ranges and Connections (Cont.)

| | | | | |
|---|---|---|---|---|
| 0 to 200 kΩ | 200 | kΩ | V-Ω, COMMON | 10 μA |
| 0 to 2000 kΩ | 2000 | kΩ | V-Ω, COMMON | 1 μA |
| 0 to 20 MΩ | 20 Meg. | kΩ | V-Ω, COMMON | 100 nA |

g. Allow time for the display to stabilize. This procedure is especially important when measuring a high value resistance shunted by a large value of capacitance.

h. Disconnect test leads.

i. If no additional, immediate resistance measurements are required, rotate the range selector switch to the 2000 1000VDC 600 VAC position and the function selector switch to the OFF position. These settings preclude accidentally applying voltage to the resistance circuits and causing the internal protective fuse to open.

## 4.7 DC CURRENT MEASUREMENTS

CAUTION

**Prior to making connections review and comply with the SAFETY PRECAUTIONS listed in paragraph 4.2.**

a. Review and comply with the Preliminary Notes and Checks, paragraph 4.3.

b. Turn the function selector switch to the DC mA position.

c. Turn the range selector switch to the appropriate current range position as indicated in Table 4-4. If the current being measured is unknown (but less than 2A), begin with the range selector switch set to the 2000 position and connect the red test lead to the mA jack and the black test lead to the COMMON jack.

d. Remove all power to the circuit being measured and discharge all capacitors.

e. Connect the test leads according to Table 4-4.

f. Open the circuit in which the current is to be measured and connect the test leads in series. Insure that the Simpson 460-2 is not connected across a voltage source which can exceed ratings of the Instrument.

g. Apply power to the circuit being measured.

h. The value of the current being measured is indicated on the numerical display. The analog reading can be used for nulling or peaking applications.

i. Remove all power from the circuit being measured and discharge all capacitors.

j. Disconnect the test leads and reconnect the circuit which was originally opened.

k. Refer to paragraph 4.6, step i.

Table 4-4. DC Current Ranges and Connections

| Range | Range Switch Position | Function Switch Position | Input Connections | Max. Current | Remarks |
|---|---|---|---|---|---|
| 0 to 200 μA | 200 μA | DCmA | mA, COMMON | 3 Amps | Auto-polarity on all ranges |
| 0 to 2 mA | 2 | DCmA | mA, COMMON | 3 Amps | Auto-polarity on all ranges |
| 0 to 20 mA | 20 | DCmA | mA, COMMON | 3 Amps | Auto-polarity on all ranges |
| 0 to 200 mA | 200 | DCmA | mA, COMMON | 3 Amps | Auto-polarity on all ranges |
| 0 to 2000 mA | 2000 | DCmA | mA, COMMON | 3 Amps | Auto-polarity on all ranges |

## 4.8 AC CURRENT MEASUREMENTS

CAUTION

**Prior to making connections, review and comply with the SAFETY PRECAUTIONS listed in paragraph 4.2.**

a. Review and comply with the Preliminary Notes and Checks, paragraph 4.3.1.

b. Turn the function selector switch to the AC mA position.

c. Turn the range selector switch to the appropriate current range position as indicated in Table 4-5. If the current being measured is unknown (but less than 2A), begin with the range selector switch set to the 2000 position and connect the red test lead to the mA jack. Connect the black test lead to the COMMON jack.

d. Remove all power from the circuit being measured and discharge all capacitors.

e. Open the circuit in which the current is to be measured and connect the test leads in series. Insure that the Simpson 460-2 is not connected across a voltage which can exceed the ratings of the Instrument.

f. Connect the test leads according to Table 4-5.

Table 4-5. AC Current Ranges and Connections

| Range | Range Switch Position | Function Switch Position | Input Connections | Max. Current | Remarks |
|---|---|---|---|---|---|
| 0 to 200 μA | 200 μA | AC mA | mA, COMMON | 3 Amps | Frequency range: 40 Hz to 10 kHz |
| 0 to 2 mA | 2 | AC mA | mA, COMMON | 3 Amps | |
| 0 to 20 mA | 20 | AC mA | mA, COMMON | 3 Amps | |

Table 4-5. AC Current Ranges and Connections (Cont.)

| | | | | |
|---|---|---|---|---|
| 0 to 200 mA | 200 | AC mA | mA, COMMON | 3 Amps |
| 0 to 2000 mA | 2000 | AC mA | mA, COMMON | 3 Amps |

g. Apply power to the circuit being measured.

h. The value of the current being measured is indicated on the numerical display. The analog display can be used for nulling or peaking applications.

i. Remove all power from the circuit being measured and discharge all capacitors.

j. Disconnect the test leads and reconnect the circuit which was originally opened.

## SECTION V

## THEORY OF OPERATION

### 5.1 OVERALL SYSTEM

The basic system block diagram for the Simpson 460-2 is shown in Figure 5.1.

**5.1.1** The parameter being measured is connected to the appropriate input terminals. The corresponding Range, Function and Signal Conditioning Circuits convert this parameter into a proportional DC voltage.

**5.1.2** This DC voltage is applied to a 3-1/2 digit bipolar (dual polarity) DC Digital Voltmeter circuit. The measured voltage is indicated on both a 7-segment LED type numerical display and an analog display. The indicated value is equal to the magnitude of the parameter being measured.

**5.1.3** The Power Supply provides the AC and DC operating voltages required by the signal conditioning and digital voltmeter circuits, and the charging circuit for the rechargeable battery.

### 5.2 INPUT CIRCUITS

**5.2.1** **DC Voltage Measurements** – The basic DC voltage measurement circuit is shown in Figure 5-2 (a). The DC

voltage being measured is connected to the V-Ω and COMMON jacks, attenuated according to the range selected and measured by the digital voltmeter circuit.

**5.2.2** The digital voltmeter circuit provides two basic full range sensitivites: 200mV and 2V. This feature simplifies the attenuator design.

a. No attenuation is required on the 200 mV and 2V ranges. The range changing on these two ranges is accomplished by changing the digital voltmeter sensitivity.

b. The same attenuator is used on the 20 V and 200 V ranges.

NOTE: A separate attenuator tap is provided for the 1000 volt range.

**5.2.3** **AC Voltage Measurements** - The basic AC voltage measurement circuit is shown in Figure 5-2 (b).

**5.2.4** The AC voltage being measured is connected to the V-Ω and COMMON jacks, attenuated according to the range selected and applied to an Input Amplifier. The output of the amplifier is converted into DC by a rectifier and the resulting DC voltage is measured by the DC Digital Voltmeter.

**5.2.5** The attenuator is not used on the 200 mV and 2 V ranges. On the higher ranges, the attenuator is frequency-compensated to provide good accuracy over a wide frequency range (refer to Table 1-1 item 3).

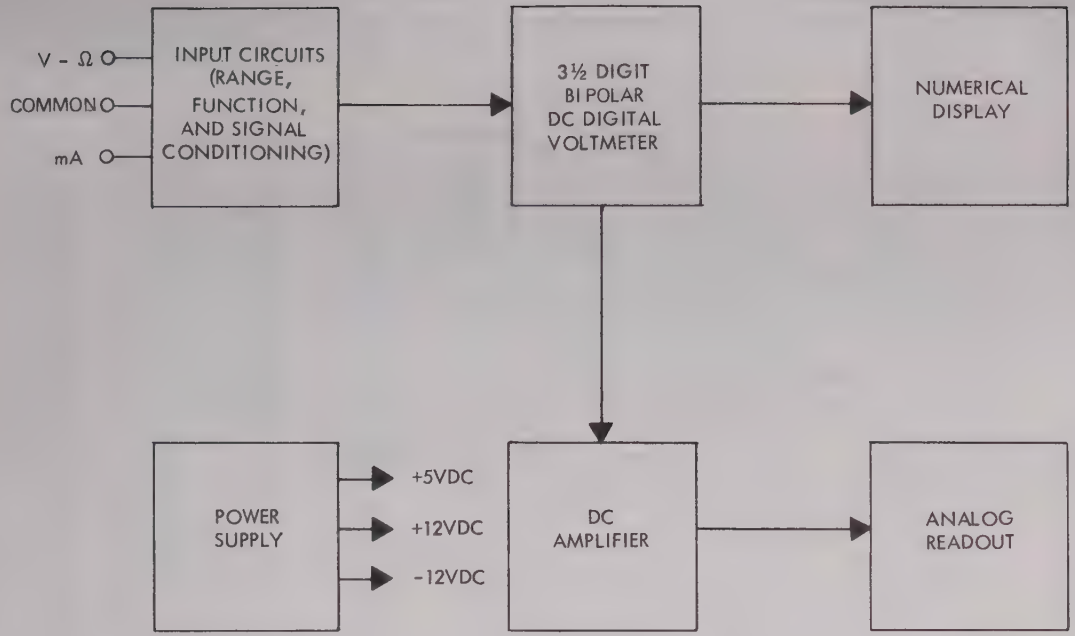


Figure 5-1. Basic System Diagram

Figure 5-2. Basic Voltage Measurement Circuits

**5.2.6** The Input Amplifier achieves a higher input impedance and presents a low output impedance to the converter.

**5.2.7** The AC to DC Rectifier uses a half-wave operational amplifier/rectifier circuit which provides two basic full range sensitivities: 200 mV and 2 V. It is average-responding but its calibration (gain) is based on the rms value of a sine wave.

**5.2.8** The output of the Operational Amplifier has two rectifying diodes and two feedback resistors, $R_1$ and $R_2$. These components drive a summing resistor $R_3$. The junction of the summing resistor and feedback resistors is connected to the amplifier input to provide negative feedback. With a sine wave input signal, the positive half cycles of the output waveform go through one diode and the negative half cycles through the other diode. The positive half cycle is filtered and the resulting DC voltage is measured by the DC Digital Voltmeter circuit.

**5.2.9** The indication on the numerical display is calibrated to the rms sine wave value being measured.

**5.2.10** **AC Current Measurements** - The basic AC current measurement circuit is essentially the same as the DC current measurement circuit (refer to 5.2.12), except that the voltage developed across the internal shunt resistance is measured by the AC voltage measurement circuit.

**5.2.11** **DC Current Measurements** - The basic DC current measurement circuit is shown in Figure 5-3.

**5.2.12** The current being measured is connected in series with the mA and COMMON jacks, across an internal precision shunt resistance. The value of the shunt resistance depends on the current range used and is selected so that the voltage developed across it numerically corresponds to the current through it. The digital voltmeter circuit measures voltage; the value indicated on the numerical display is equal to the current being measured.

**5.2.13** The full range sensitivity of the digital voltmeter circuit is 200 mV. The internal resistance for each current range equals 200 mV divided by the full range current. For example, if the full range current is 200 μA, the internal resistance is 1000 ohms.

**5.2.14 Resistance Measurements -** The basic resistance circuit is shown in Figure 5-3.

**5.2.15** The resistance being measured, $R_X$, is connected to the V-Ω and COMMON jacks and a constant current is applied through it by the Instrument. The resulting voltage is proportional to the value of $R_X$. The value of the current used depends upon the range selected.

**5.2.16** The current through $R_X$ is controlled by an Operational Amplifier whose inputs "follow" $E_X$ and the output is always $E_X$ + 1 volt. The 1 volt reference for the amplifier is developed by the current from a Constant Current Source through a 1000Ω feedback resistor.

**5.2.17** The $E_X$ + 1 volt output of the amplifier maintains

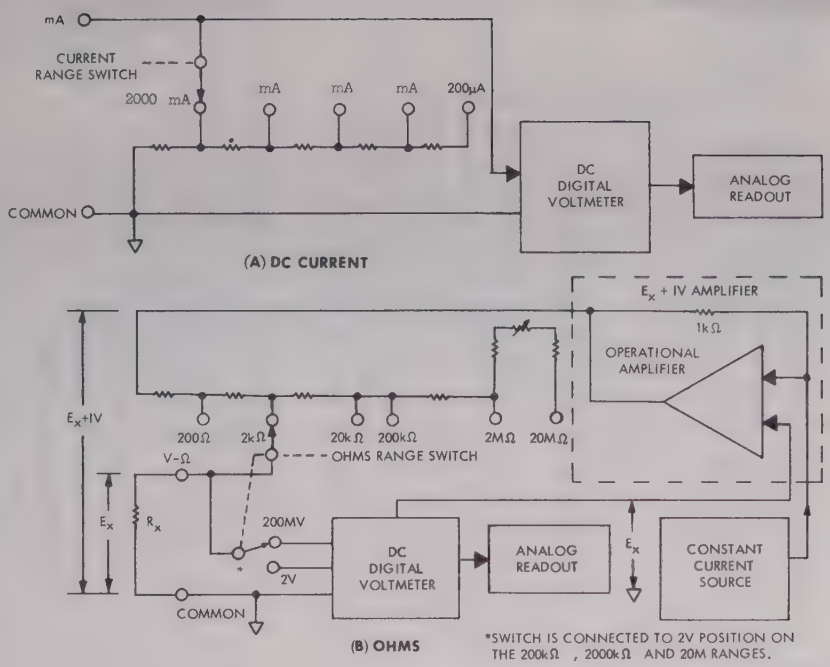


Figure 5-3. Basic DC Current and Resistance Measurement Circuits

a constant current through $R_X$ regardless of the value of $R_X$. The magnitude of the current is determined by the resistance (precision resistors selected by the ohms range switch) in series with $R_X$.

**5.2.18** The digital voltmeter measures the voltage developed across $R_X$ and the value indicated on the numerical display is equal to the resistance or $R_X$, in units set by the range switch.

## 5.3 DIGITAL VOLTMETER CIRCUIT

**5.3.1** The basic block diagram of the digital voltmeter circuit is shown in Figure 5-4. The circuit utilizes the dual-slope integration technique for the analog-to-digital conversion. This technique achieves excellent accuracy, stability, and noise immunity. The term dual-slope is derived from the two slope operation of the integrator.

**5.3.2** The incoming DC voltage is sampled and measured at the input of the integrator at typically 4 times per second. The sampling interval T1 is initiated by a pulse from the Zero Detector circuit and the measuring interval, T2, by an "overflow" pulse from the Counter Circuits in the LSI package. See Figure 5-5 for the basic timing diagram (shown for a positive input signal).

**5.3.3** During T1, the integrating capacitor charges and the Integrator output voltage increases in accordance with the polarity and magnitude of the input signal. At the same

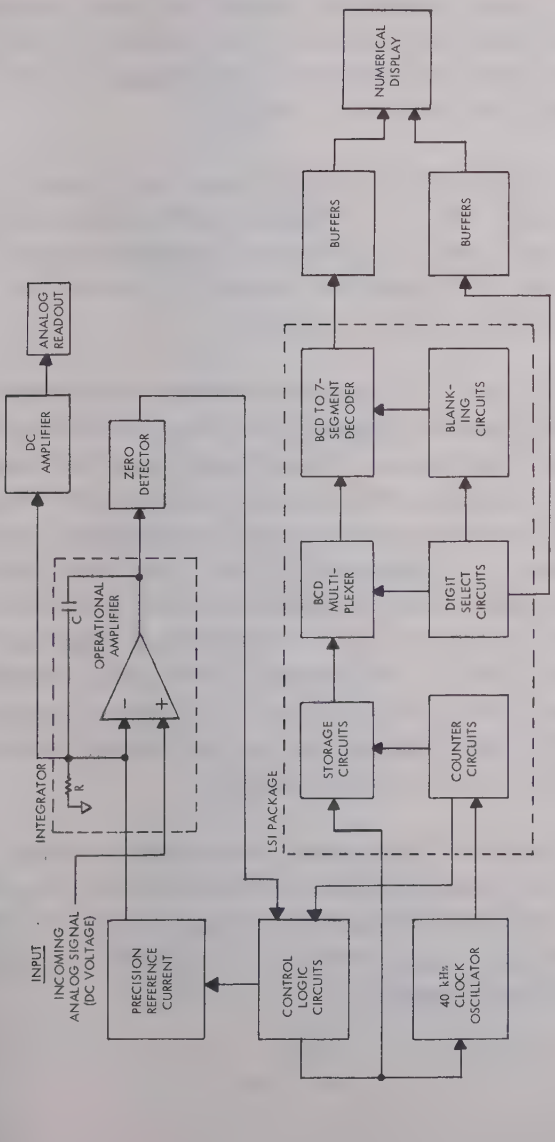


Figure 5-4. Digital Voltmeter, Block Diagram

time, the Counter Circuits are counting the pulses generated by the 40 kHz Clock Oscillator. At a count of 10,000 an "overflow" pulse is generated by the Counter Circuits and the counters reset to the "zero" state.

**5.3.4** The "overflow" pulse actuates the Control Logic Circuit which selects a Precision Current Reference of proper polarity and connects it to the Integrator input. At this time, the first integrating interval T1, is ended and the second integrating interval, T2, starts.

**5.3.5** During T2, the reference current causes capacitor C to discharge, and the voltage at the output of the Integrator to decrease towards zero. At the same time, the Counter Circuits are counting the pulses generated by the 40 kHz clock. The counting continues until the Integrator output reaches zero. At cross-over of zero, the Zero Detector generates a pulse, which, through the Control Logic Circuits, momentarily stops the clock oscillator and transfers the accumulated count to the Storage Circuits as an equivalent BCD (Binary Coded Decimal)signal. The second integrating internal, T2, now is ended, the reference current is disconnected and the cycle repeats (T1 starts).

**5.3.6** The BCD Multiplexer sequentially transfers the signals in the Storage Circuits to the BCD–to–7–segment Decoder. The BCD Multiplexer is controlled by the Digit Select Circuits, which consist of an oscillator and a four-line (4 bit binary) decoder.

Figure 5–5. Simpson 460-2, Basic Timing Diagram

**5.3.7** The BCD–to–7–segment Decoder converts the BCD signals into seven signals suitable for interfacing with a 7-segment LED display. The 7-segment outputs and the Digit Select outputs are synchronously applied to the LED display. The display digits are sequentially energized with each digit updated several hundred times per second. The numerical and polarity indications correspond to the value of the analog signal at the input of the Integrator.

**5.3.8** The other requirements of the digital voltmeter circuits, such as overrange, out-of-range blanking and polarity indications, are accomplished within the Control Logic and LSI package.

## 5.4 POWER SUPPLY CIRCUITS

The basic block diagram for the 460-2 power supply circuits is shown in Figure 5-6.

**5.4.1** When the Simpson 460-2 is operated from an AC power line, the incoming AC power is applied to transformer T1. The two primary windings are connected in series for 240 volt (nominal), and in parallel for 120 volt (nominal) operation. T1 steps down the voltage as required by the Rectifier Circuit.

**5.4.2** The Rectifier Circuit is a full-wave, bridge type which converts the incoming AC into two unregulated DC voltages. The lower unregulated voltage is applied to a series type regulator circuit. The output from the regulator is

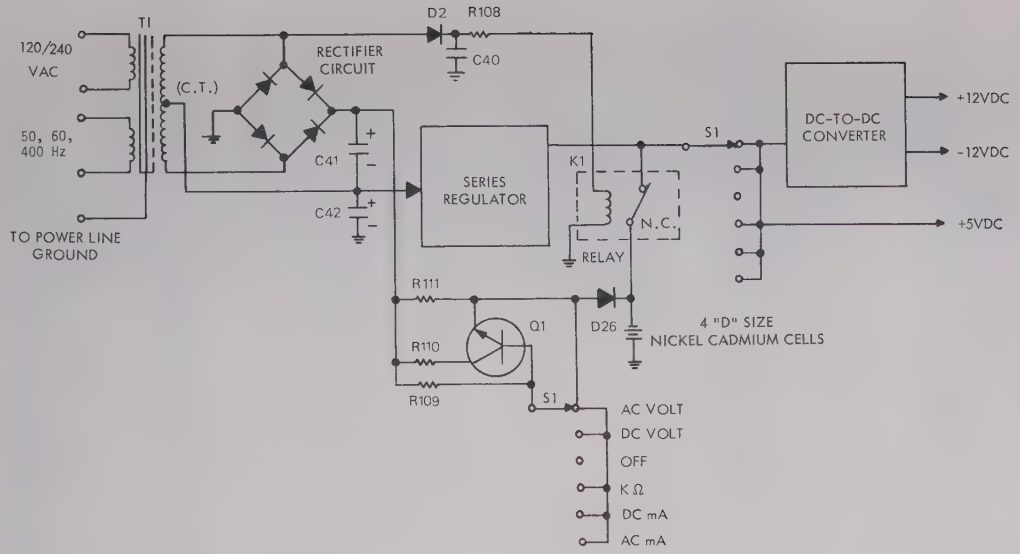


Figure 5–6. Simpson 460-2 Power Supply, Schematic

5 volts. The paths via R111 and R110 provide the proper charging current for the battery.

NOTE: The relay automatically sets the circuit for battery charge when the AC power line is connected to the Instrument.

**5.4.3** The DC–to–DC Converter changes the +5 volts DC (regulator or battery voltage) into a high-frequency AC signal. This AC signal then is stepped up and rectified and regulated to provide outputs of + and – 12 volts DC.

# SECTION VI

# MAINTENANCE

## 6.1. GENERAL

**WARNING**

**This Instrument contains internal voltages which constitute a SHOCK HAZARD. Before attempting to adjust, calibrate or repair this Instrument, review and comply with the SAFETY PRECAUTIONS outlined in paragraph 4.2. Preferably, only Simpson Authorized Service Centers or factory personnel will disassemble any part of the Instrument.**

The Simpson 460-2 is carefully designed and constructed with high quality components. By providing reasonable care and following the instructions in this manual, the user can expect a long, useful service life from his Instrument.

## 6.2 WARRANTY

The Simpson Electric Company Warranty policy is printed on the inside back cover of this manual. Read carefully prior to requesting a warranty repair.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact your nearest Authorized

Service Center for instructions. These Centers are listed on the last pages of the manual. If you wish to contact the factory directly, give full details of the difficulty and date of purchase. Service data or shipping instructions will be sent to you promptly. If an estimate or charges for non-warranty or other service work is required, a maximum charge estimate will be quoted. This charge will not be exceeded without your prior approval.

## 6.3 SHIPPING

**6.3** Pack the Instrument carefully and ship it prepaid to the proper destination. Insure the Instrument.

## 6.4 COVER REMOVAL

The top cover can be removed for maintenance purposes by the following procedures:

CAUTION

**Remove all power and connections to the Instrument prior to removing the case cover.**

**6.4.1** Rotate the function switch to the OFF position.

**6.4.2** Disconnect the line cord from the power source and all connections from the Instrument.

**6.4.3** Remove the two Phillips head screws near the

front on each side of the cover and loosen the two rear screws.

**6.4.4** Position the handle upright (top of case); then lift the front of the cover upward, pull forward to clear rear screws and remove.

**6.4.5** Reverse this procedure when replacing the cover.

## 6.5 BATTERY INSTALLATION

**6.5.1** Recommended cells: Four "D" size 1.25 V, 4 ampere-hours, nickel-cadmium rechargeable ( Eveready type CH4), or equal.

CAUTION

**Standard carbon zinc or alkaline "D" size cells can be used in an emergency. However, the power line fuse must be removed to prevent charging these cells in the Instrument. These cells do not have provision for pressure relief and can burst when charged. Immediately remove the cells when the emergency is over or when they are discharged and replace with nickel-cadmium cells at your earliest convenience.**

**6.5.2** Install the cells as follows:

a. Remove cover (refer to 6.4). Remove the cells in

retainer tubings from the battery holder. Insert two cells into each retainer. Then install the combination into the holder. Insure that the cells are installed according to the polarity orientation designated on the battery holder label. Failure to do so can damage the 460-2.

b. Check that the battery contacts are clean and making good connection.

c. Replace the cover.

d. For battery recharging, refer to paragraph 6.6, below.

e. Test the battery according to paragraph 4.3.2.

## 6.6 BATTERY RECHARGING

**6.6.1** The battery is being charged at full rate when the function selector switch is set to the OFF position and AC power is applied to the Instrument. Approximately 16 hours are required to fully charge the battery in this mode of operation.

NOTE: If the battery voltage checks below +4.7 volts, charge the battery with the function selector switch set to OFF for at least 15 minutes before operating the Instrument.

**6.6.2** The battery is being charged at a reduced rate whenever the Instrument is operated by the AC power line. Approximately 30 hours are required to fully charge the battery under this condition. Test the battery according to paragraph 4.3.2.

## 6.7 BATTERY CARE

**6.7.1** Avoid discharging the cells completely. Check the battery voltage periodically using the BATTERY TEST jack (refer to paragraph 4.3.2). Charge the battery whenever the voltage is close to or below +4.7 volts.

**6.7.2** Do not operate the Instrument with discharged cells. Make sure to recharge all newly purchased batteries (refer to 6.6.1 above) for at least 15 minutes before operating the Instrument.

**6.7.3** Whenever the line cord is not connected and the Instrument is not in use, remember to turn the function switch to the OFF position.

**6.7.4** With nickel-cadmium cells installed in the 460-2, avoid storing in an area where the temperature exceeds +60 C.

## 6.8 FUSE REPLACEMENT

The line fuse, current fuse, and ohms fuse are mounted inside fuse-holders on the rear panel as shown in Figure 6-1. Use the following procedure to replace a fuse.

CAUTION

**Remove all power and input connections to the Instrument prior to removing fuse.**

**6.8.1** Press the bottom of the fuse cap to remove fuse.

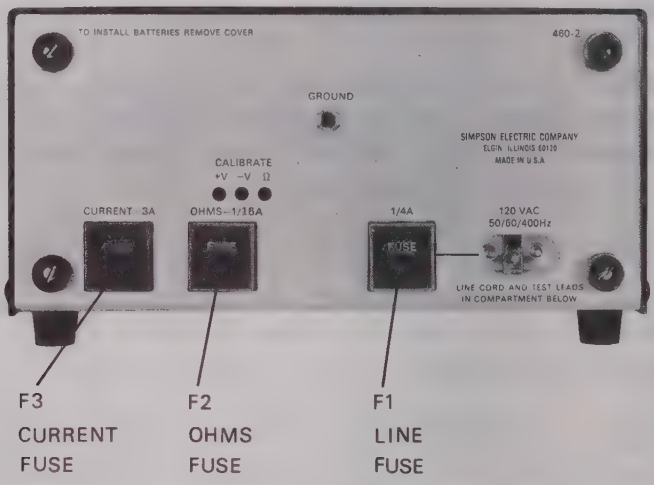


Figure 6-1. Simpson 460-2 Fuse Location.

**6.8.2** Carefully lift the cap from the holder and replace with appropriate fuse according to the following:

F1, line fuse (for 120 V operation): 1/4A 250 V, Type 3AG, fast blow.
(for 240 V operation): 1/8A 250 V, Type 3AG, fast blow.
F2, Ohms Fuse: 1/16A, 250 V, Type 3AG, fast blow.
F3, Current Fuse: 3A, 250 V, Type 3AG, fast blow.

**6.8.3** Install fuse cap into holder by applying a firm pressure on center of cap until it snaps in place.

CAUTION

**Do NOT replace a blown fuse with a fuse which has a larger rating or slower time lag characteristic than those specified.**

## 6.9 ZERO ADJUSTMENT

**6.9.1** The Simpson 460-2 has been calibrated at the factory using precision instruments. The stability of the Instrument precludes the need for frequent recalibration. However, should "zero adjustment" be required after a long period of time, or extreme temperature ambient conditions, use the following procedure:

a. Connect test leads to the V-Ω and COMMON terminals.

b. Turn the function selector switch to the DCV position.

c. Turn the range selector switch to the 200 mV position.

d. Short the test leads together.

e. Allow the Instrument to warm up for 30 minutes.

f. Using an insulated screwdriver, adjust the ZERO potentiometer on the front panel.

## 6.10 KNOB REMOVAL

CAUTION

**Do not operate the Simpson 460-2 without knobs, nor use knobs (or set screws) which differ from those originally supplied with the Instrument.**

**6.10.1** For optimized performance, the shafts of the function and range switches are connected to the COMMON input terminal. Therefore, if the COMMON terminal is "floated" (away from power line ground) a shock hazard can exist between the shafts and power line ground. The shafts are insulated from the user by the knob design and by having the fastening set screws below the knob surface.

**6.10.2** As an added precaution, each fastening set screw (metal) is covered with a nylon set screw.

**6.10.3** To remove or replace a knob:

a. Remove the nylon set screw to provide access to the fastening set screw.

b. Loosen fastening set screw (requires 1/16" hex key wrench) and remove knob.

c. To reinstall the knob or to install a replacement knob, reverse the above procedure. Do not forget to install the nylon set screw.

## 6.11 PREVENTIVE MAINTENANCE

### 6.11.1 Daily Care:

a. Immediately clean all spilled materials from the Instrument and wipe dry.

CAUTION

**Do not attempt to clean this Instrument with the test leads connected to a power source or when it is connected to the AC power line.**

b. Avoid allowing the battery to fully discharge. Complete discharge of the battery might cause permanent damage to the cells. Check the battery voltage according to paragraph 4.3.2.

c. Whenever possible, avoid exposure or usage in areas which are subject to: temperature and humidity exposures, vibration or mechanical shock, dust or corrosive fumes, or strong electrical or electromagnetic interferences.

### 6.11.2 Monthly Care:

Verify Instrument calibration by performing operational checks using known value sources. If the need for calibration is indicated, contact your nearest Authorized Simpson Service Center.

### 6.11.3 Annual Care:

It is recommended that the Instrument be returned annually to a Simpson Authorized Service Center or the factory for a complete overall check, adjustment and calibration.

### 6.11.4 Storage:

When the Instrument is not in use, store it in a location free from temperature extremes, dust and corrosive fumes, and mechanical vibration or shock.

## 6.12 TROUBLE SHOOTING

**6.12.1** If the Instrument does not yield satisfactory results, follow this procedure, prior to attempting maintenance on the Instrument:

a. Review and comply with the Preliminary Notes and Checks, listed in paragraph 4.3.

b. Check that all controls are positioned correctly for the parameter and range of value being measured and that the measurement situation is within the ratings of the Instrument.

c. If the Instrument is battery operated, be sure that the cells are charged and are properly installed (refer to paragraph 6.5).

d. If the Instrument is AC line operated, insure that power source is within the Instrument specifications, and free from excessive fluctuations and transients.

e. Insure that the environment in which the Instrument is being used is within the Instrument specifications.

f. Inspect the device being measured and the measurement test set-up to insure that proper shielding and grounding techniques have been used. If power line effects are

suspected, operate the Instrument on a battery. Also consider whether the Instrument is significantly affecting the circuit being measured.

**6.12.2** If the steps taken in paragraph 6.12.1 do not yield satisfaction, refer to the trouble shooting chart (Table 6-1). Direct all other repair and adjustment needs to a Simpson Authorized Service Center.

## Table 6-1. Troubleshooting Chart

| Symptom | Probable Causes | Cure |
|---|---|---|
| 1. No indication on numerical and analog display when Instrument is battery operated. AC operation is OK. | Cells – Discharged, defective, not installed properly, making poor contact, or missing. | Check battery voltage. Refer to para. 4.3.2. If OK contact nearest Simpson Authorized Service Center. |
| 2. LOW intensity on numerical display in battery operation. | Cells not fully charged. | Check battery voltage. Refer to para. 4.3.2. If battery checks low, remove cover and check that the cells are installed correctly and making good contact. Refer to 6.5. If they are, replace cover and charge battery overnight. Refer to para. 6.6. |
| 3. No indication on the numerical and analog displays when Instrument is AC line operated (no cells installed). | a. Low or no voltage at power source receptacle.<br>b. Line cord disconnected.<br>c. Defective line cord.<br>d. Line fuse open. | a. Restore correct voltage at power receptacle.<br>b. Connect line cord.<br>c. Repair or replace line cord.<br>d. Replace line fuse. Refer to 6.8. |

Table 6-1. Troubleshooting Chart (continued)

| Symptom | Probable Causes | Cure |
|---|---|---|
| 4. Batteries do not respond to charge. Instrument operation OK when connected to AC power. | Cells defective, not installed properly, making poor contact, or missing. | Remove cover and check that cells are installed correctly and making good contact. Refer to 6.5. If they are, check the voltages of the individual cells. Replace those which check significantly lower than nominal (1.25 volts). |
| 5. Operation normal on all functions and ranges except on K-Ω ranges. | Ohms fuse F2 open. | Replace fuse F2. Refer to 6.8. |
| 6. Operation normal on all functions and ranges except AC and DC current. | Current fuse F3 open. | Replace fuse F3. Refer to 6.8. |

Table 6-1. Troubleshooting Chart (continued)

| Symptom | Probable Causes | Cure |
|---|---|---|
| 7. Indications fluctuate and/or drift, even though indication is OK at 000 with the input terminals shorted, and at 1000 counts when using a stable and low impedance input. | Fluctuations and/or drift are being generated by the device being measured or the measurement test set up. | Use proper shielding, grounding techniques, and connections to minimize "pick-up" of unwanted signals due to ground loops, poor connections, and capacitive and/or inductive coupling. Operate Instrument on battery for complete isolation from the power line.<br><br>NOTE: If the drift and/or fluctuation is coming from the device being measured, no cure is required, the measurement is valid, and the device must be corrected. |

| Symptom | Probable Causes | Cure |
|---|---|---|
| 8. Indication is OK on battery. However, on AC operation, the reading fluctuates and/or drifts at 0, with the input shorted, and/or at 1000 counts using a stable and low impedance input. | AC power source is low or fluctuating (including transients). | Correct the power source or use Instrument on battery. |
| 9. Same as 8 above, except indication OK on AC but not on battery operation. | a. Battery voltage low. | a. Check battery condition. Refer to para. 4.3.2. If not OK charge battery, refer to para. 6.6. |
| | b. One or more cells defective, not installed correctly | b. Remove cover and check that cells are installed correctly and making good contact. If OK, replace all cells temporarily with conventional carbon zinc "D" size cells for checking purposes only. If problem still exists, contact nearest S Simpson Authorized Service Center. |

Table 6-1. Troubleshooting Chart (continued)

| Symptom | Probable Causes | Cure |
|---|---|---|
| 10. Slow response. Operation OK when using a low impedance input. | Parameter being measured has a high source impedance. | None required. |
| 11. Accuracy not within specifications when checked with a stable, higher accuracy (at least 5 times better) low impedance (voltage measurements) source. | a. Instrument is out of calibration.<br>b. Instrument not zeroed properly | a. Contact nearest Simpson Authorized Service Center.<br>b. Perform ZERO adjustment. Refer to para. 6.9. |
| 12. Accuracy of Instrument is within specifications but measurements appear in error. | a. Instrument affects circuit being measured.<br>b. Common and/or normal mode specification is being exceeded. | a. Study circuit being measured vs. Instrument specifications. Correct indications accordingly.<br>b. Refer to cure in item 7 above. |

# SECTION VII

# ORDERING INFORMATION, SCHEMATIC DIAGRAM, AND AUTHORIZED SERVICE CENTERS

Table 7-1. Items Furnished With Instrument

| Quantity | Description | Part No. |
|---|---|---|
| 1 | Test Lead Set: One black and one red insulated lead having probe tips with provision for screw-on alligator clips (one red and one black supplied). | 00115 |
| 1 | Operator's Manual | 5-116602 |

Table 7-2. Replacement Parts List

| Symbol | Description | Part No. |
|---|---|---|
| | AC Line cord | 5-112790 |
| | Knob. Function & Range | 5-115583 |
| | Set screw, nylon | 5-115670 |
| | Test leads, red | 86-922480 |
| | Test lead, black | 86-922480 |
| | Alligator clips (without insulator) | 1-115963 |
| | Insulator, alligator clips, red | 5-112479 |
| | Insulator, alligator clip, black | 5-111169 |
| C1 | Capacitor, .1μf, Ceramic Disc 20V | 5-114521 |
| C2 | Capacitor, .1μf, Ceramic Disc 20V | 5-114521 |
| C3 | Capacitor, 62pf ±5% 300V | 5-116187 |
| C4 | Capacitor, 1μf, 100V Met. Poly. | 5-113612 |
| C5 | Capacitor, 100pf ±10%, 1kV | 5-113217 |
| C6 | Capacitor, 2.7μf ±10%, 100V | 5-116590 |
| C7 | Capacitor, .01μf ±20%, 100V | 5-113215 |
| C8 | Capacitor, 100pf ±10%, 1kV | 5-113217 |
| C9 | Capacitor, .01μf ±20%, 100V | 5-113215 |
| C10 | Capacitor, 100pf ±10%, 1kV | 5-113217 |
| C11 | Capacitor, .01μf ±20%, 100V | 5-113215 |
| C12 | Capacitor, 2500pf ±20%, 1kV | 5-113985 |
| C13 | Capacitor, .001μf ±20%, 1kV | 5-111119 |
| C14 | Capacitor, .001μf ±20%, 1kV | 5-111119 |
| C15 | Capacitor, .001μf ±20%, 1kV | 5-111119 |
| C16 | Capacitor, 250pf ±10%, 1kV | 5-113216 |
| C17 | Capacitor, .001μf ±20%, 1kV | 5-111119 |
| C18 | Capacitor, .01μf ±20%, 100V | 5-113215 |
| C19 | Capacitor, 15μf -20+50%, 16V | 5-115534 |
| C20 | Capacitor, .1uf ±10%, 630V | 5-115529 |
| C21 | Capacitor, 300μf, 6V | 5-115537 |

Table 7-2. Replacement Parts List (Cont)

| Symbol | Description | Part No. |
|---|---|---|
| C22 | Capacitor, 10pf ±5%, 2500V | 5-115165 |
| C23 | Not Used | |
| C24 | Capacitor, Trimmer, 2-8pf | 5-115528 |
| C25 | Capacitor, Trimmer, 15-60pf | 5-115527 |
| C26 | Capacitor, 450pf, ±2.5% | 5-115821 |
| C27 | Capacitor, 5000pf, ± 2.5% | 5-115776 |
| C28 | Capacitor, 15μf -20+50% | 5-115534 |
| C29 | Capacitor, 15μf -20+50% | 5-115534 |
| C30 | Capacitor, 15μf -20+50% | 5-115534 |
| C31 | Capacitor, 39pf ±5% | 5-115820 |
| C32 | Capacitor, 15μf -20+50% | 5-115534 |
| C33 | Capacitor, 15μf -20+50% | 5-115534 |
| C34 | Capacitor, 6pf ±5pf | 5-115539 |
| C35 | Capacitor, 15μf -20+50% | 5-115534 |
| C36 | Capacitor, 2.2μf ±10% | 5-115533 |
| C37 | Capacitor, 1μf ±10% | 5-115531 |
| C38 | Capacitor, .47μf ±10% | 5-115530 |
| C39 | Capacitor, 15μf -20+50% | 5-115534 |
| C40 | Capacitor, 15μf -20+50% | 5-115534 |
| C41 | Capacitor, 1500μf, 12V | 5-116591 |
| C42 | Capacitor, 2200μf, 12V | 5-116592 |
| C43 | Capacitor, .02μf, GMV | 1-110652 |
| C44 | Capacitor, 15μf -10+75% | 5-115536 |
| C45 | Capacitor, 1μf, 20V | 5-114521 |
| C46 | Capacitor, 1μf, 20V | 5-114521 |
| C47 | Capacitor, 15μf -10+75% | 5-115536 |
| C48 | Capacitor, 15μf -20+50% | 5-115534 |
| C49 | Capacitor, 510pf ±5% | 5-115542 |

Table 7-2. Replacement Parts List (Cont)

| Symbol | Description | Part No. |
|---|---|---|
| C50 | Capacitor, 510pf ±5% | 5-115542 |
| D1 | Diode, Silicon, Bridge Rect. | 5-115945 |
| D2 | Diode, Silicon, 100PIV, 1AMP | 5-114005 |
| D3 | Diode, Zener, 7.5V ±5% | 5-116601 |
| D4 | Diode, Silicon, 100PIV, 1 AMP | 5-114005 |
| D5 | Diode, Silicon, Bridge Rect. | 5-115945 |
| D6 | Diode, Zener, 13V ±5% | 5-112726 |
| D7 | Diode, Zener, 13V ±5% | 5-112726 |
| D8 | Diode, Zener, 4.7V ±5% | 5-115476 |
| D9 | Diode, Silicon, 75PIV, 75mA | 5-112004 |
| D10 | Diode, Silicon, Schottky Barrier | 5-115774 |
| D11 | Diode, Silicon, Schottky Barrier | 5-115774 |
| D12 | Diode, Silicon, 25PIV, 200mA | 5-114946 |
| D13 | Diode, Silicon, 25PIV, 200mA | 5-114946 |
| D14 | Diode, Rectifier, 50PIV, 3AMP | 5-115475 |
| D15 | Diode, Rectifier, 50PIV, 3AMP | 5-115475 |
| D16 | Diode, Rectifier, 50PIV, 3AMP | 5-115475 |
| D17 | Diode, Rectifier, 50POV, 3AMP | 5-115475 |
| D18 | Diode, Silicon, 75PIV, 75mA | 5-112004 |
| D19 | Diode, Silicon, 75PIV, 75mA | 5-112004 |
| D20 | Diode, Silicon, 75PIV, 75mA | 5-112004 |
| D21 | Diode, Silicon, 75PIV, 75mA | 5-112004 |
| D22 | Diode, Silicon, 75PIV, 75mA | 5-112004 |
| D23 | Diode, Zener Ref., 6.2V ±5% | 5-112721 |
| D24 | Diode, Silicon, 75PIV, 75mA | 5-112004 |
| D25 | Diode, Zener Ref., 6.2V ±5% | 5-112721 |
| D26 | Diode, Silicon, 100PIV, 1AMP | 5-114005 |

Table 7-2. Replacement Parts List (Cont)

| Symbol | Description | Part No. |
|---|---|---|
| F1 | Fuse, 1/4A, 3AG | 1-113835 |
| F2 | Fuse, 1/16A, 3AG | 5-116792 |
| F3 | Fuse, 3A, 3AG | 5-115272 |
| IC1 | MOS 4-Digit Counter/Display | 5-116597 |
| IC2 | Integrated Circuit, Oper. Amplifier | 5-115467 |
| IC3 | Integrated Circuit, Diff. Comparator | 5-115470 |
| IC4 | Integrated Circuit, Oper. Amplifier | 5-116598 |
| IC5 | Integrated Circuit, Oper. Amplifier | 5-115468 |
| IC6 | Integrated Circuit, Oper. Amplifier | 5-116598 |
| IC7 | Integrated Circuit, Hex Inverter | 5-115469 |
| IC8 | Integrated Circuit, Quad. 2-Input Gate | 5-115471 |
| IC9 | Integrated Circuit, Triple 3-Input Gate | 5-116599 |
| IC10 | Integrated Circuit, Quad. 2-Input Gate | 5-115471 |
| IC11 | Integrated Circuit, Dual D Flip-Flop | 5-115472 |
| K1 | Relay, Reed N.C. Form B | 5-116243 |
| LED-1 | Readout, LED, 7-Segment | 5-115943 |
| LED-2 | Readout, LED, 7-Segment | 5-115943 |
| LED-3 | Readout, LED, 7-Segment | 5-115943 |
| LED-4 | Readout, LED, ±1 | 5-115944 |
| M1 | Indicating Instrument | SC-000016 |

Table 7-2. Replacement Parts List (Cont)

| Symbol | Description | Part No. |
|---|---|---|
| Q1 | Transistor, NPN Silicon | 5-115932 |
| Q2 | Transistor, NPN Silicon | 5-115934 |
| Q3 | Transistor, NPN Silicon | 5-115932 |
| Q4 | Transistor, NPN Silicon | 5-115934 |
| Q5 | Transistor, NPN Silicon | 5-115934 |
| Q6 | Transistor, NPN Silicon | 5-115934 |
| Q7 | Transistor, PNP Silicon | 5-116198 |
| Q8 | Transistor, NPN Silicon | 5-113193 |
| Q9 | Transistor, NPN Silicon | 5-113193 |
| Q10 | Transistor, NPN Silicon | 5-112631 |
| Q11 | Transistor, NPN Silicon | 5-112631 |
| Q12 | Transistor, NPN Silicon | 5-112631 |
| Q13 | Transistor, Junction Field Eff. | 5-115483 |
| Q14 | Transistor, PNP Silicon | 5-115484 |
| Q15 | Transistor, NPN Silicon | 5-112631 |
| Q16 | Transistor, PNP Silicon | 5-113864 |
| Q17 | Transistor, NPN Silicon | 5-112631 |
| Q18 | Transistor, Dual, NPN Silicon | 5-113035 |
| Q19 | Transistor, Dual, PNP Silicon | 5-115478 |
| Q20 | Transistor, PNP Silicon | 5-113864 |
| Q21 | Transistor, NPN Silicon | 5-112631 |
| Q22 | Transistor, PNP Silicon | 5-113864 |
| Q23 | Transistor, NPN Silicon | 5-112631 |
| Q24 | Transistor, PNP Silicon | 5-113864 |
| Q25 | Transistor, NPN Silicon | 5-112631 |
| Q26 | Transistor, PNP Silicon | 5-113864 |
| Q27 | Transistor, NPN Silicon | 5-112631 |
| Q28 | Transistor, PNP Silicon | 5-113864 |
| Q29 | Transistor Package | 5-116600 |

Table 7-2. Replacement Parts List (Cont)

| Symbol | Description | Part No. |
|---|---|---|
| R1 | Resistor, 100k ±1%, 1/2W | 5-111408 |
| R2 | Resistor, 100k ±1%, 1/2W | 5-111408 |
| R3 | Resistor, 90k ±1%, 1/4W | 5-115526 |
| R4 | Resistor, 4.99k ±1%, 1/4W | 5-115502 |
| R5 | Pot, 5k ±10%, 1/2W, WW | 5-115520 |
| R6 | Resistor, 4.99k ±1%, 1/4W | 5-115502 |
| R7 | Resistor, 2k ±1%, 1/4W | 5-115491 |
| R8 | Resistor, 10 Ohms ±1%, 1/4W | 5-115487 |
| R9 | Resistor, 2k ±1%, 1/4W | 5-115491 |
| R10 | Pot, 1k ±10% Cermet | 5-116474 |
| R11 | Resistor, 17.6k ±1%, 1/4W | 5-115496 |
| R12 | Resistor, 100k ±1%, 1/4W | 5-115506 |
| R13 | Resistor, Prec. Metal Film V. Divider | 5-115582 |
| R14 | Resistor, 8.2 Meg, ±2%, 1/4W | 5-115655 |
| R15 | Pot, 1 Meg ±10%, 1/2W Cermet | 5-116586 |
| R16 | Resistor, 100k ±1%, 1/4W | 5-115506 |
| R17 | Resistor, 22k ±10%, 1/4W | 5-113623 |
| R18 | Resistor, 22k ±10%, 1/4W | 5-113623 |
| R19 | Resistor, 900 ±1/10%, 75W | 5-115578 |
| R20 | Resistor, 90.0 ±1/10%, 75W | 5-115577 |
| R21 | Resistor, 9.0 ±1/10%, 75W | 5-115576 |
| R22 | Resistor, 0.9 ±1/10%, 1.25W | 5-115575 |
| R23 | Resistor, 0.1 ±1/10%, 1.25W | 5-115574 |
| R24 | Resistor, 402 ±1%, 1/4W | 5-116772 |
| R25 | Resistor, 100 ±10%, 1/4W | 5-114968 |
| R26 | Resistor, 10k ±1%, 1/4W | 5-114962 |
| R27 | Resistor, 10k ±1%, 1/4W | 5-114962 |

Table 7-2. Replacement Parts List (Cont)

| Symbol | Description | Part No. |
|---|---|---|
| R28 | Resistor, 1.5k ±10%, 1/4W | 5-113872 |
| R29 | Resistor, 150 ±10%, 1/4W | 5-115510 |
| R30 | Resistor, 12k ±10%, 1/4W | 5-114879 |
| R31 | Resistor, 56k ±10%, 1/4W | 5-115513 |
| R32 | Resistor, 56k ±10%, 1/4W | 5-115513 |
| R33 | Resistor, 56k ±10%, 1/4W | 5-115513 |
| R34 | Resistor, 56k ±10%, 1/4W | 5-115513 |
| R35 | Resistor, 8.2k ±10%, 1/4W | 5-114977 |
| R36 | Resistor, 8.2k ±10%, 1/4W | 5-114977 |
| R37 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |
| R38 | Resistor, 18k ±10%, 1/4W | 5-115512 |
| R39 | Resistor, 12k ±10%, 1/4W | 5-114978 |
| R40 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |
| R41 | Resistor, 12k ±10%, 1/4W | 5-114978 |
| R42 | Resistor, 12k ±10%, 1/4W | 5-114978 |
| R43 | Resistor, 12k ±10%, 1/4W | 5-114978 |
| R44 | Resistor, 825 ±1%k 1/4W | 5-115499 |
| R45 | Pot, 2k ±10%, 1/2W Cermet | 5-116477 |
| R46 | Resistor, 11.5k ±1%, 1/4W | 5-116585 |
| R47 | Resistor, 825 ±1%, 1/4W | 5-115499 |
| R48 | Resistor, 11.5k ±1%, 1/4W | 5-116585 |
| R49 | Pot, 2k ±10%, 1/2W Cermet | 5-116477 |
| R50 | Resistor, 1k ±1%, 1/4W | 5-115490 |
| R51 | Resistor, 5.76k ±1%, 1/4W | 5-115504 |
| R52 | Pot, 1k ±10%, 1/2W Cermet | 5-116123 |
| R53 | Resistor, 22k ±10%, 1/4W | 5-113623 |
| R54 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |
| R55 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R56 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |

Table 7-2. Replacement Parts List (Cont)

| Symbol | Description | Part No. |
|---|---|---|
| R57 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R58 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |
| R59 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R60 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R61 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |
| R62 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R63 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R64 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |
| R65 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R66 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R67 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |
| R68 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R69 | Resistor Package, 150, 8 Resis. | 5-116581 |
| R70 | Resistor Package, 10k, 7 Resis. | 5-116582 |
| R71 | Resistor, 330 ±10%, 1/4W | 5-114970 |
| R72 | Resistor, 330 ±10%, 1/4W | 5-114970 |
| R73 | Pot, 22k ±20%, 1/10W | 5-115523 |
| R74 | Resistor, 33k ±10%, 1/4W | 5-113875 |
| R75 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |
| R76 | Resistor, 12k ±10%, 1/4W | 5-114978 |
| R77 | Resistor, 33k ±10%, 1/4W | 5-113875 |
| R78 | Resistor, 3.3k ±10%, 1/4W | 5-114973 |
| R79 | Resistor, 1 Meg ±5%, 1/2W | 1-117538 |
| R80 | Resistor, 495k ±1/10%, 1/4W | 5-115498 |
| R81 | Resistor, 495k ±1/10%, 1/4W | 5-115498 |
| R82 | Resistor, 9.00k ±1/10%, 1/4W | 5-115492 |
| R83 | Resistor, 1k ±1/10%, 1/4W | 5-115489 |
| R84 | Resistor, 49.9k ±1%, 1/4W | 5-115525 |
| R85 | Resistor, 22k ±10%, 1/4W | 5-113623 |

Table 7-2. Replacement Parts List (Cont)

| Symbol | Description | Part No. |
|---|---|---|
| R86 | Resistor, 6.8k ±10%, 1/4W | 5-114976 |
| R87 | Pot, 1k ±20%, 1/10W, Carbon | 5-116185 |
| R88 | Resistor, 8.45k ±1%, 1/4W | 5-115494 |
| R89 | Resistor, 90.0k ±1/10%, 1/4W | 5-115497 |
| R90 | Resistor, 9.96 ±1/10%, 1/4W | 5-115493 |
| R91 | Pot, 100 ±10%, 1/2W Cermet | 5-116589 |
| R92 | Resistor, 510 ±1%, 1/4W | 5-115488 |
| R93 | Resistor, 10.0k ±1%, 1/4W | 5-114962 |
| R94 | Resistor, 10.0k ±1%, 1/4W | 5-114962 |
| R95 | Resistor, 10.0k ±1%, 1/4W | 5-114962 |
| R96 | Resistor, 30.1k ±1%, 1/4W | 5-115505 |
| R97 | Resistor, 30.1k ±1%, 1/4W | 5-115505 |
| R98 | Resistor, 30.1k ±1%, 1/4W | 5-115505 |
| R99 | Resistor, 100k ±10%, 1/4W | 5-115514 |
| R100 | Resistor, 1.5k ±10%, 1/4W | 5-113872 |
| R101 | Resistor, 100k ±10%, 1/4W | 5-115514 |
| R102 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R103 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R104 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R105 | Resistor, 10k ±10%, 1/4W | 5-113624 |
| R106 | Resistor, 22k ±10%, 1/4W | 5-113623 |
| R107 | Resistor, 22k ±10%, 1/4W | 5-113623 |
| R108 | Resistor, 680 ±10%, 1/4W | 5-113869 |
| R109 | Resistor, 1k ±10%, 1/4W | 5-113871 |
| R110 | Resistor, 43 ±10%, 5W | 5-116583 |
| R111 | Resistor, 62 ±10%, 5W | 5-116584 |
| R112 | Resistor, 330 ±10%, 1/4W | 5-114970 |
| R113 | Resistor, 2.7 ±10%, 1/4W | 5-116364 |

Table 7-2. Replacement Parts List (Cont)

| Symbol | Description | Part No. |
|---|---|---|
| R114 | Resistor, 560 ±10%, 1/4W | 5-115511 |
| R115 | Pot, 470 ±20% Carbon | 5-116236 |
| R116 | Resistor, 1.5k ±10%, 1/4W | 5-113872 |
| R117 | Resistor, 100k ±10%, 1/2W | 1-113949 |
| R118 | Resistor, 820 ±10%, 1/4W | 5-113870 |
| R119 | Resistor, 22 ±10%, 1/4W | 5-115509 |
| R120 | Resistor, 100 ±10%, 1/4W | 5-114968 |
| R121 | Resistor, 100 ±10%, 1/4W | 5-114968 |
| R122 | Resistor, 1k ±10%, 1/4W | 5-113871 |
| R123 | Resistor, 1k ±10%, 1/4W | 5-113871 |
| R124 | Resistor, 22 ±10%, 1/4W | 5-115509 |
| S1 | Switch, Function | 5-115449 |
| S2 | Switch, Range | 5-115448 |
| T1 | Transformer, Power | 5-116605 |
| T2 | Transformer, DC-DC | 5-116604 |

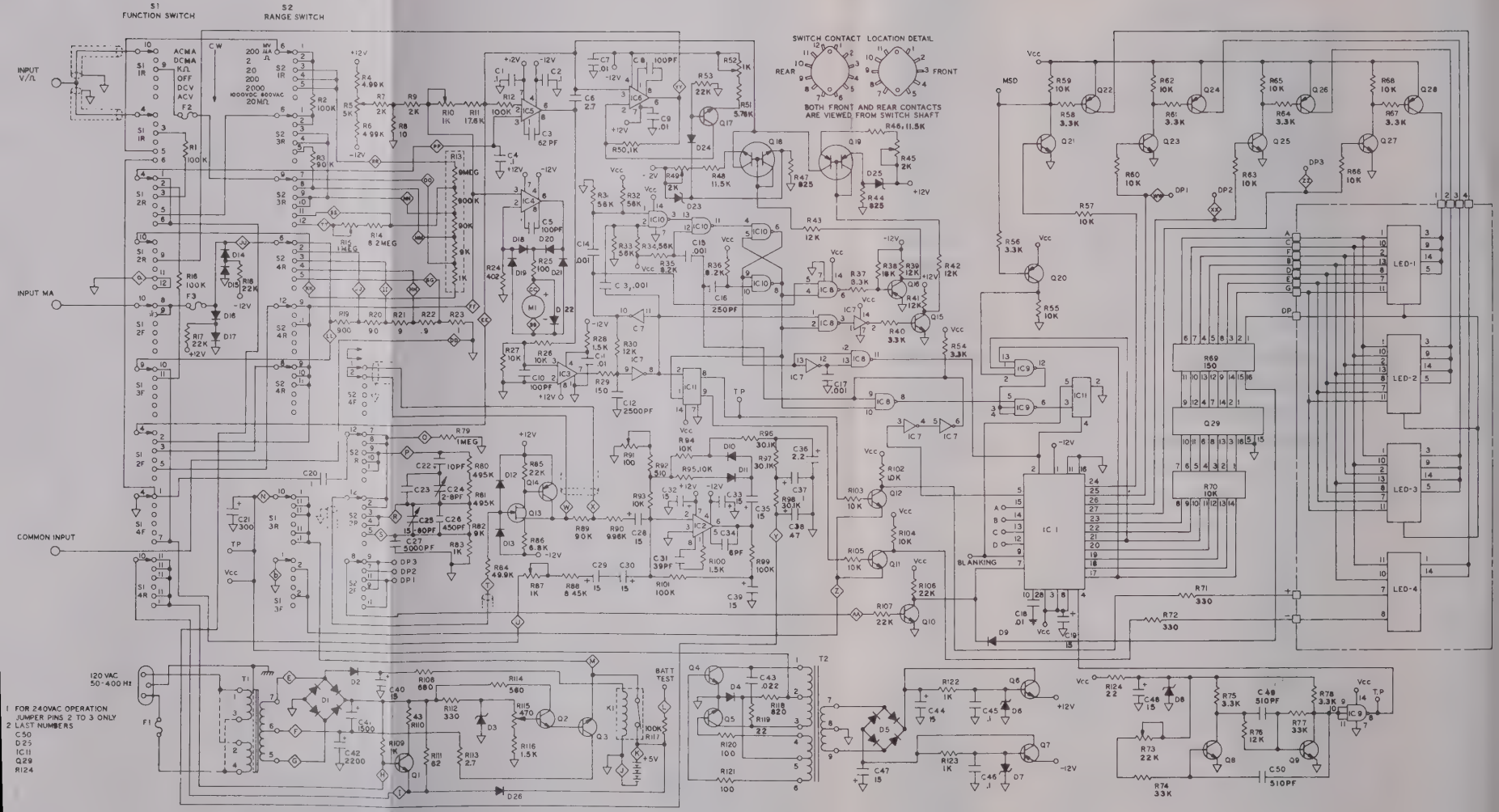


Figure 7–1. Simpson 460-2, Schematic Diagram

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